Universal norm psychology leads to societal diversity in prosocial behavior and development

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Abstract

Recent work has proposed that social norms play a key role in motivating human cooperation, and in explaining the unique scale and cultural diversity of our prosociality. However, there has been little work directly linking social norms to the form, development, and variation in prosocial behavior across societies. In a cross-cultural study of eight diverse societies, we provide evidence that (1) adults' prosocial behavior is predicted by what other members of their society judge to be the correct social norm, (2) children's responsiveness to novel social norms develops similarly across societies, and (3) societally-variable prosocial behavior develops concurrently with children's responsiveness to norms in middle childhood. These data support the view that the development of prosocial behavior is shaped by a psychology for responding to normative information, which itself develops universally across societies.

Introduction

Human cooperative abilities are core to our success as a species [1,2] and differ in at least two important ways from those of other animals. First, people orchestrate group-level cooperation with large numbers of unrelated individuals. Second, cooperative behaviors vary considerably across societies [3,4], and this variation emerges during middle childhood [5-9]. Some have suggested that the evolution of both can be explained if human social preferences are at least partly shaped by local cultural norms [5], which we acquire through an evolved psychology for learning and conforming to social norms [6,7]. According to this claim, we can explain what makes humans so successful by demonstrating (1) that our prosocial behavior is linked to social norms, and (2) that we have a universally-developing psychology for responding to these norms.

Norms are central to numerous theoretical models of human sociality and development [5,8–11], and are generally conceived of as phenomena that regulate behavior through prescriptions and proscriptions [12]. Following Bicchieri [8,13], we define a social norm as a behavior rule that individuals conform to when they believe that: (a) a sufficiently large number of people in their community conforms to the rule (empirical expectation), and (b) a sufficiently large number of people in their community expects them to conform to the rule (normative expectations). A descriptive norm, in contrast, would focus on empirical expectations. There is already some evidence that norms underlie variation in prosociality across societies and groups [4,14]. However, most studies have only documented this variation across societies or explained it using society-level variables [3,15]. What is needed is empirical evidence that societal variation in normative expectations gives rise to variation in prosocial behaviors. Such evidence would show that individuals' prosocial behavior is predicted by what members of their society believe to be normatively 'correct' in a particular situation (social norms). We must also distinguish the influence of social norms from that of individuals' own beliefs about what is 'correct' (personal norms).

To connect societal variation in prosocial behavior to the development of a universal psychology for social norms, we must also show that across diverse societies children's tendency to respond to social norms is increasing during the same period that adult-like prosocial behavior is forming. Children are sensitive to normative information as young as 1.5-4 years of age [16]. At this age, they enforce norm conformity in others [17], follow descriptive and injunctive norms [18,19], are sensitive to moral and conventional rules [20], and they know that different groups follow different norms [17]. Later, in middle childhood, children demonstrate an increasing responsiveness to novel social norms in experimental settings [18], suggesting that children of this age are becoming increasingly committed to modifying their behavior to conform to social norms. Interestingly, this is the same age that societal variation in children's prosocial choices appears to emerge in costly sharing tasks (i.e. tasks which involve a choice between outcomes that benefit oneself and outcomes that benefit others) [15,21–24]. These findings suggest that middle childhood is a particularly important period for the adoption of locally-appropriate prosocial behaviors, and this could be the product of children's increasing responsiveness to social norms at this age. As children are already sensitive to norms by the time that they reach middle childhood, changes in behavior during middle childhood may be due to developmental changes in their willingness to conform to norms, particularly their willingness to conform to norms which impose costs on them.

If societal variation in adults' prosocial behavior is linked to societal beliefs about correct prosocial choices, this provides evidence that prosocial behavior is motivated by social norms above and beyond personal norms (Prediction 1). If children's responsiveness to social norms is developing during childhood, then with increasing age their prosocial choices should become more adult-like and variable across societies (Prediction 2), and also more strongly influenced by novel social norms (Prediction 3). This would provide two independent sources of evidence for the hypothesis that social norms have increasing influence on children's prosocial behavior as they mature, and would be consistent with the results of prior studies. If children's willingness to respond to norms develops similarly across a wide range of different societies, it would provide evidence for a universally-developing human psychology for responding to social norms (Prediction 4). If this societally-common responsiveness to norms develops concurrently with the development of adult-like prosocial behavior, it would provide evidence that a universally-developing psychology for social norms can explain the emergence of societal variation in prosocial behavior (Prediction 5).

We conducted field experiments on prosocial behavior using the Dictator Game (DG) as a measure of costly sharing with 255 adults (131 female) and 833 children (414 female) aged 4-17, in eight populations ranging from foragers to small-scale horticulturalists to large urban communities (Table 1). The DG provides a well-validated test of an individual's willingness to share with others at a personal cost, and its standardized design facilitates direct comparison across populations (Figure 1) [25]. We used a binary-choice version of the DG in which subjects chose between two options: they could keep two rewards and give none to an absent anonymous peer (the "2/0", self-maximizing option), or they could keep one reward and give one to the peer (the "1/1", prosocial option). This version of the task is appropriate for children aged ≥4 years and adults [15,26,27]. All child and adult subjects included in the dataset passed three comprehension questions confirming they understood the DG procedure, the content of the norm prime videos, and that larger quantities of rewards resulted in higher payoffs (Supplementary Information pg.25).

Before each subject made their choice in the DG, they viewed a short video in which an adult model verbalized novel normative information about the two options in the DG (we refer to this normative information as the 'norm prime') [18]. Videos used a standardized script, but were recorded at each fieldsite using local translations of the script and local adults as models. Across three between-subjects conditions participants were presented with different norm primes. In the GENEROUS condition, the norm prime indicated that 1/1 was 'right' and 'good to choose', while 2/0 was 'wrong' and 'bad to choose'. In the SELFISH condition, the norm prime indicated that 2/0 was 'right'/'good to choose' and 1/1 was 'wrong'/'bad to choose'. Importantly, the videos did not show the model making a choice in the DG, they simply presented the norm prime as if musing about the choice between 1/1 and 2/0. In the BOTH OK condition, the model stated that 1/1 and 2/0 were both 'ok'/'ok to choose', language that isn't strongly normative but which could arguably be at least weakly normative. Regardless, BOTH OK provides a reference point about subjects' prosocial choices when they have been given information that does not preferentially bias them towards either 1/1 or 2/0 (as the GENEROUS and SELFISH conditions had done).

To test Prediction 1, adult subjects in all eight societies received only the BOTH OK norm prime before they made their choice in the DG. We used these data to assess variation in the probability of adults' 1/1 choices across societies. In seven of the eight societies we also elicited judgments about which norm prime was 'correct' (practical limitations required using an abbreviated procedure with the Hadza, precluding collection of data on judgments; Supplementary Information pg.28). In these seven societies, after subjects had made their choice in the DG, they were presented with both the GENEROUS and SELFISH norm prime videos (randomizing the order of presentation), and asked which of the videos they believed to be "more correct". This judgement could be influenced both by what participants believe is correct for them to choose (personal norms), and also by what they believe is correct for others to choose (social norms). If individuals' DG choices are influenced by social norms, then their choices are expected to be predicted by the judgments of others in their society (i.e. others' beliefs about what is the 'correct' norm) in addition to their own judgments. Subjects' judgments allow us to study how society-level beliefs influence prosocial behavior, without requiring subjects to explicitly report what they think other members of their community believe to be correct. This is important for a cross-cultural study, as comfort and familiarity with discussing others' thoughts or mental states varies across societies [28].

To test Prediction 2, a subset of child subjects in all eight societies also received the BOTH OK prime, and we explored how the probability of children's 1/1 choices changes with age in the BOTH OK condition. To determine how adult-like prosocial behavior develops, we explored whether children's prosocial choices were predicted by the prosocial choices of adults from their own society, and whether this relationship changed as a function of children's age.

To test Prediction 3, in six of the eight societies two additional subsets of children were presented with either the GENEROUS or SELFISH norm primes (practical limitations prevented testing these additional samples in both Tanna and Hadza) in a between-subjects design. We explored whether the GENEROUS prime increased the probability of 1/1 choices relative to the BOTH OK prime, and whether the SELFISH prime decreased this probability relative to the BOTH OK prime. If subjects' prosocial choices in the DG were responsive to the normative information provided by the priming videos, then subjects are expected to be more likely to choose 1/1 in GENEROUS than in BOTH OK, and less likely to choose 1/1 in

BOTH OK than in SELFISH. To test Prediction 4, we then explored whether the development of children's responsiveness to the primes varied across societies.

To test Prediction 5, we compared the development of adult-like DG choices in children, the development of children's responsiveness to novel social norms (e.g. GENEROUS, SELFISH norm primes), and the development of children's tendency to make choices consistent with adults' beliefs about social norms (i.e. the probability that adults in their society judged GENEROUS to be 'most correct'). If these different developmental trajectories align, and if children's responsiveness to novel social norms develops similarly across societies, this will suggest that societal variation in prosocial development is linked to the development of a universal psychology for responsiveness to social norms.

Results

Prediction 1. We explored whether adults DG choices varied across societies by comparing regression models using WAIC and AIC weight (Table 2). Model 1a represents the hypothesis that DG choices do not vary across societies. Model 1b represents the hypothesis that DG choices vary across societies and includes dummy parameters for each society. We had no predictions about Age and Gender for adult subjects, but Model 1c included interactions with these variables to consider whether they were important. Model 1b provides a better fit to the data than the other models (reflected by lower WAIC and higher AIC weight; Table 2), indicating that the probability of a 1/1 choice varied substantially across societies, and that this variation was not a by-product of variation in the distribution of Age or Gender across societies (the estimates of Models 1c and 1b are similar; Supplementary Figure 12).

The probability that adults would choose the 1/1 option varied across societies (Model 1b; Fig.2a; Supplementary Table 3). Information about mean amounts given in a continuous DG were available for three of the societies in our sample (from a previous study), and the proportion of 1/1 choices in the present binary DG (Americans=.54, Shuar=.20, Hadza=.20) were similar to the mean amounts given in the continuous DG (Americans=.45, Shuar=.34, Hadza=.26; triangles in Fig.2a) [4]. This suggests that societal variation in choices is stable across different versions of the DG, and also that our experiment elicits a form of prosocial behavior that has been linked to cultural adaptations related to religious beliefs, market norms, and norms for living in large communities [3–5,29]. This also implies that the BOTH OK prime does not alter individuals' preferences in the DG.

The probability that adults judge the GENEROUS norm prime to be "more correct" also varied across societies (Model 2; Fig.2b; Supplementary Table 3). To determine whether societal differences in judgments about 'correct' norms predicted subjects' DG choices, we constructed a two-stage model. The first stage of Model 3 was equivalent to Model 2, and estimated the probability that adults in each society would judge GENEROUS to be more correct. The second stage predicted adults' 1/1 choices in the DG using: (1) the first-stage estimates of the probability that GENEROUS would be judged to be more correct in an adult subject's society, and (2) adults' own judgments as to whether GENEROUS was more correct. Both of these parameters predicted adults' DG choices. Subjects' were more likely to choose 1/1 if they themselves later judged the GENEROUS norm prime to be more correct (Fig.2c; Coef=1.61, StDev=0.33, 95%CIs=0.96,2.27; Supplementary Table 4). Subjects were also more likely to choose the 1/1 option if they lived in a society where people were generally more likely to judge the GENEROUS norm prime to be more correct (Fig.2c; Coef=0.46, StDev=0.22, 95%CIs=0.08,0.93; Supplementary Table 4).

Prediction 2. We explored whether children's DG choices changed with age in the BOTH OK condition (the same condition presented to adults) by again comparing models using WAIC and AIC weight (Table 3). Model 4a included society dummy parameters only (the same structure as Model 1b), representing the hypothesis that DG choices vary across societies but do not change with age. Model 4b represents the hypothesis that children's choices changed with age, by including interactions between society dummies and Child Age. Model 4c included an Age^2 parameter to explore whether a u-shaped effect of age would improve model fit, and Model 4d included interactions between society dummies and subject Gender. Model 4b provides a better fit to the data than the other models, reflected in a higher AIC weight (Table 3). There is a large standard error for the difference in WAIC for Model 4a, so we report the results for both Model 4a and 4b in Supplementary Table 5. These analyses suggest that children's 1/1 choices changed with age, which is illustrated by plotting Model 4b (Fig.3a). Plotting the estimates of Models 4c and 4d suggests they produce qualitatively similar results (see Supplementary Figures 13-14).

We explored whether children's DG choices became increasingly like those of adults with age, using a two-stage model (Model 5). The first stage was similar to Model 1b, and estimated the probability that adults in each society would choose the 1/1 outcome. The second stage predicts each child's DG choice using the first stage estimates of the probability that adults from their society would chose 1/1, and included an interaction between the first stage estimates and child age. The interaction was reliable, indicating that with increasing age children's DG choices were increasingly predicted by the DG choices of adults (Coef=0.55, StDev=0.27, 95%CIs=0.09,1.16; Supplementary Table 6). Plotting this relationship shows that the model predicts children's choices become positively related to adults' choices after about age 8, with this estimate becoming reliably different from zero after about age 10 (Fig.3b).

Predictions 3 and 4. We explored whether children's DG choices were influenced by norm primes by comparing models of children's choices in all three conditions (BOTH OK, GENEROUS, SELFISH) in the six societies for which these data were available (excluding Tanna and Hadza), once more comparing models using WAIC and AIC weight (Table 4). Model 6b represents the hypothesis that children responded to norm primes, by including dummy parameters for the GENEROUS and SELFISH conditions. Model 6a represents the hypothesis that children did not respond to norm primes, by excluding these parameters (the same model structure as Model 4b). Model 6c represents the hypothesis that children's responsiveness to norm primes changes with age, by including interactions between Child Age and dummies for GENEROUS and SELFISH. Model 6d represents the hypothesis that the development of a responsiveness to norm primes varies across societies, by including three-way interactions with society dummies, Child Age, and dummies for GENEROUS and SELFISH.

Model 6c provides a substantially better fit to the data than Model 6a or Model 6d (Table 4). This suggests that children were responsive to norm primes and that this responsiveness developed similarly across societies. Model 6c had a slightly larger AIC weight than Model 6b (Table 4), indicating that both models fit the data well, but the inclusion of parameters for Child Age improved model fit to some extent. In both Models 6b and 6c there are reliable effects for the GENEROUS dummy (Model 6b: Coef=1.47, StDev=0.20, 95%CIs=1.07,1.86; Model 6c: Coef=1.47, StDev=0.20, 95%CIs=1.07,1.86; note: nearly identical estimates; Supplementary Table 7) and also for the SELFISH dummy (Model 6b: Coef= -1.00, StDev=0.24, 95%CIs= -1.48,-0.52; Model 6c: Coef= -1.03, StDev=0.25, 95%CIs= -1.52,-0.54; Supplementary Table 7). This means that children were substantially more likely to choose 1/1 when they received the GENEROUS norm prime (relative to BOTH OK), and substantially less likely to choose 1/1 when they received the SELFISH norm prime.

Model 6c also provides evidence of an interaction between Child Age and GENEROUS that is borderline reliable, as the lower CI is zero (Coef=0.40, StDev=0.21, 95%CIs=0.00,0.81; Supplementary Table 7), while the interaction between Child Age and SELFISH is clearly not reliable (Coef=0.29, StDev=0.25, 95%CIs= -0.19,0.78; Supplementary Table 7). This suggests a modest developmental increase in children's responsiveness to the GENEROUS norm prime but not to the SELFISH norm prime. Plotting these model estimates (Fig.4a) indicates that children are somewhat more likely to choose 1/1 in GENEROUS than in BOTH OK across the entire age range, but this responsiveness to GENEROUS is only reliable after about age 6-7, and increases through middle childhood. Plotted estimates also suggest that children are somewhat less likely to choose 1/1 in SELFISH across the entire age range, but this responsiveness to SELFISH is less pronounced, less consistently reliable, and shows little sign of change with age.

The model comparison analysis in Table 4 implies that the development of children's responsiveness to norm primes did not vary substantially across societies. To confirm this, we plotted the results of Model 6d separately for each of the six societies (Fig.4b-4g). All of the societies reveal a responsiveness to the norm primes. For four of the societies (La Plata, Shuar, Pune, and Wichí) the results are qualitatively consistent with the overall developmental pattern in Figure 4a: responsiveness to norm primes becomes reliable sometime around age 6-7 and thereafter increases, particularly for the GENEROUS norm prime. The developmental pattern for responsiveness to the SELFISH norm prime seems to be more inconsistent, plausibly due to a floor effect in some societies in which children are unlikely to choose 1/1 in the BOTH OK condition. For the two other societies (Berlin and Phoenix), reliable differences between each of the conditions appear to emerge by age 4 or earlier, and children's responsiveness to the norm primes appears to change somewhat less with age (with the exception of reduced responsiveness to the SELFISH norm prime in older children in Phoenix).

Prediction 5. We explored the relationship between children's DG choices and adults' DG choices (as for Prediction 2) in the six societies in which we investigated responsiveness to norm primes. This afforded the closest comparison between the development of adult-like DG choices and the development of a responsiveness to norm primes. Model 7 used the same two-stage structure as Model 5, and produced the same result: convergence between children's and adults' 1/1 choices increased with age (Coef=0.85, StDev=0.42, 95%CIs=0.15,1.81; Supplementary Table 8). Using the same approach and model structure, Model 8 explored the relationship between children's DG choices and adults' judgments. This model shows that with age children's 1/1 choices were increasingly predicted by the estimated probability that adults from their society would judge GENEROUS to be more correct (Coef=0.61, StDev=0.24, 95%CIs=0.20,1.16; Supplementary Table 9). Plotting both of these results shows that from about age 8 children's choices are positively related to both adults' DG choices and adults' judgments, and this relationship was reliable from about age 9-10 (Fig.3c-3d). These analyses reveal that adults' DG choices and judgments both predict children's choices, but not whether these are independent effects (when both parameters are included in a single model, neither effect is reliable; Supplementary Table 10).

Discussion

This study presents three main findings: (1) cross-cultural variation in adults' prosocial behavior is related to what members of their society judge to be the 'correct' prosocial norm (Prediction 1); (2) in middle childhood and early adolescence children's prosocial behavior becomes increasingly similar to adults' prosocial behavior (Prediction 2), and also increasingly similar to adults' judgments about the 'correct' prosocial norm; (3) by middle childhood children in very different societies develop a uniform tendency to respond to novel social norms about prosocial behavior, and this coincides with the development of adult-like societal variation in that behavior (Predictions 3, 4 and 5). Together, these findings link societal variation in prosociality to the development of a universal psychology for responding to social norms.

Adults' DG choices were predicted by the probability that members of their society would judge the generous norm prime to be more correct. This effect was independent of the influence of individuals' personal norms, indicating that individuals' prosocial choices were related to local social norms (i.e. society-level beliefs about what is correct). We note that this need not have been the case: individuals' personal norms could have been the only factor predicting decisions, and other differences across communities (e.g. relatedness, community size, migration rates) could have created enough societal variation in prosocial choices to swamp the influence of societal-level norms.

During middle childhood children's prosocial choices became increasingly predicted by the prosocial choices of adults from their own societies, with this relationship emerging by about age 8-10 at the latest. This is consistent with findings from prior studies showing that societal variation in prosociality and fairness emerges during middle childhood and early adolescence [15,21,22]. We extend this work to show that during middle childhood (by age 8-10) children's choices become increasingly predicted by the probability that adults from their society would judge generous norm primes to be more correct. This is consistent with our finding that adults' own prosocial choices were predicted by local beliefs about what is ‘correct’, and it reinforces the idea that during this developmental period children’s prosocial choices are becoming both more adult-like and more attuned to local prosocial norms. Future studies should explore whether these are independent developmental phenomena, and whether children’s prosocial behavior is better predicted by adults’ prosocial behavior or judgments about local norms.

Although children’s prosocial choices generally became more adult-like with age, there were exceptions to this pattern. For example, in Pune and Tanna older children were less likely to choose 1/1 than were adults. In both of these sites, adults chose 1/1 with a probability close to 0.5, and they also judged the GENEROUS norm prime to be ‘more correct’ with a probability close to 0.5. This suggests that adults in these communities held a variety of beliefs about correct norms for behavior in the DG, and this heterogeneity could complicate children’s attempts to navigate towards adult-like patterns of behavior. This interpretation is supported by the pattern of variation in the Phoenix sample. In Phoenix, adults chose 1/1 with a probability close to 0.5, but they were much more likely to judge the GENEROUS norm prime to be ‘more correct’. This suggests that there was a greater consensus in beliefs about prosocial norms in the DG in Phoenix than in Pune and Tanna, and it may explain why children in Phoenix seemed to follow the overall trend towards adult-like behavior. The lack of clearly adult-like choices for children in Berlin may be an artifact of the composition of the sample. In Berlin, the oldest children in our BOTH OK sample are only about age 10, the age at which reliably adult-like choices begin to emerge.

In prior studies with the DG, we found that children were more generous in early childhood than in middle childhood [15,27], a u-shaped pattern that we did not replicate here. This may be due to different experimental procedures. Previously, subjects were face-to-face with their partners, while in the present study subjects were alone and anonymous. By about age 5, children are more likely to be selfish when they are unobserved [30,31], but it is unlikely that children younger than age 5 use anonymity strategically as they are not very good at managing their reputation [32]. It is more plausible that the lack of face-to-face contact with a partner in our study reduced social factors, such as empathy [33] and a desire to interact with others [34], factors that are more likely to motivate prosociality at this age. Future work should directly compare the influence of these factors (as well as motivations such as strategic reciprocity [23,35–37], kin biases [38], and group biases [39]) with the influence of norms on costly prosocial behavior in early and middle childhood.

Our experiments show that novel social norms influenced children's prosocial choices. Children's responsiveness to novel norms developed similarly across societies, generally increasing with age and becoming a reliable effect by about age 6-8. This suggests that children's sensitivity to novel norms is growing at the same age at which their choices are also becoming more adult-like and more consistent with adults' judgments about correct behavior. Evidence for a developmental increase in children's responsiveness to generous norm primes was modest, but this nonetheless provides evidence for developmental changes in children's willingness to pay a cost to conform to a norm.

Developmental changes may have been obscured by children's responsiveness to norms emerging somewhat earlier in some societies than in others. For four societies (La Plata, Shuar, Pune, Wichí), responsiveness to generous norm primes became reliable by about age 6-8, and seemed to increase through middle childhood. However, for two societies (Berlin and Phoenix) reliable responsiveness emerged by age 4. This implies broad cross-cultural similarity in development, but also some variation in timing. This is consistent with prior work showing that the foundations of moral evaluation [40], prosocial behavior [41], and normative behavior are present early in childhood [16–20]. It also supports the proposal that adult-like prosocial behavior emerges due to increases in children's responsiveness to normative information, rather than fundamental changes in their ability to conform to norms (given that in at least some societies this is present earlier).

Our studies suggest that the emergence of adult-like prosocial behavior is linked to the development of children's responsiveness to normative information. Future research should explore in detail how children's willingness to respond to norms changes during middle childhood, and how the development of this willingness predicts children's tendency to behave like adults. In Phoenix and Berlin, children younger than age 6-8 were willing to pay a cost to conform to norms, but they did not make very adult-like choices in the BOTH OK condition. In these societies, children's responsiveness to norms in early childhood may be based less on a general interest in behaving normatively, and more on a tendency to interpret normative information as 'what adults want them to do'. If adults in these societies tend to strongly encourage and enforce normative behavior at young ages, children may have learned to simply do whatever adults say the right thing to do is. This highlights that the critical developmental change in middle childhood is likely an increasing willingness to pay a cost to behave normatively, and it will be crucial for future studies to ask how this is shaped by other aspects of psychological development, such as increases in perspective taking or mental state reasoning, emotional development and cognitive inhibition [42].

Equally important will be understanding the role of social environment, which has a crucial influence on prosocial behavior in infancy [43], and may also affect prosocial behavior later in childhood. For example, children's choices in costly sharing tasks become markedly more egalitarian if they have been exposed to civil warfare between the ages of 7 and 12, but not if the exposure occurred earlier in development (age 3-6) [44], and these effects seem to persist across the lifespan. Although the results of the present study are most informative about the development of children's responsiveness to normative information in personally-costly cooperative dilemmas, it will also be important to explore how children's responsiveness develops differently across domains or contexts.

Future work should also explore other strategies for modeling the nature of social norms within communities. Our strategy was based on the estimated probability with which individuals in a society judged generous norms to be 'most correct', an approach similar to what has been used in prior studies. In a study of costly punishment in 15 societies, individuals' decisions about whether to punish selfishness in third-parties were predicted by the mean amount that members of their society gave in a DG [4]. Similarly, in a study of cooperation across camps of Hadza foragers, individuals' contributions in a public goods game were predicted by the mean contribution of members of their camp in the same game [14]. This suggests that modeling norms using the frequency of a behavior (or the probability of particular normative judgments) is an effective strategy, but other approaches may be even better, for example a more conformist approach [6,45]. Future experiments should also explore the content of norms in other ways, for example by eliciting judgments from subjects about what others in their society do or expect them to do, or judgments about how similar the game is to real-world situations.

Our findings show that societal variation in prosocial behavior is linked to beliefs about 'correct' social norms. They also demonstrate that prosocial behavior becomes increasingly adult-like and normative during middle childhood, and that during this same period children across societies develop a tendency to respond (at a personal cost) to social norms about prosocial behavior. In so doing, this project illustrates how the development of a universal norm psychology can lead to the emergence of societal variation in prosociality, and it adds to the growing evidence that humans' unique forms of cooperation are highly dependent on acquired cultural norms and institutions.

Methods

All research and consent procedures were approved by the appropriate university ethical review boards at: Arizona State University (IRB ID: STUDY00001591), Cambridge Psychology Research Ethics Committee (PRE.2016.026), Simon Fraser University Office of Research Ethics (Study Number: 2013s0335; Study Title: Prosocial Development in Vanuatu and Canada). All appropriate national and community bodies also gave consent for the research, at all of our fieldsites. The authors affirm that human research participants provided written informed consent, for publication of the images in Figure 1. Images of participants were taken by experimenters from video recordings of experimental trials. The authors also affirm that human research participants provided written informed consent for video recordings.

Participants: See Table 1 and Supplementary Table 1.

Dictator Game: Children participated in a binary choice Dictator Game (DG), in which the experimental Subject decided between two pre-determined payoff distributions, referred to below as “ratios”. Test ratio #1: 1 for Subject, 1 for Recipient (i.e., 1/1). Test ratio #2: 2 for Subject, 0 for Recipient (i.e., 2/0).

Apparatus and procedure: Where between-subjects conditions were used, subjects were randomly assigned to conditions. Data was collected by fieldworkers familiar with the research design and hypotheses, and so was not blind. The apparatus consisted of two laminated paper trays, each with a red and a blue circle on them, which were placed in front of the Subject (Supplementary Information, pg.23). Each tray corresponded to one of the two DG test ratios, with tokens placed in the red circle going to the Subject, and tokens placed in the blue circle going to the Recipient. The Recipient wasn’t present during the study, but was represented by a small wooden person-shaped figurine. Recipients and Subjects were anonymous. The experimenter placed tokens on the trays, and the Subject then selected one of the trays. Recipients were real, and rewards were delivered to them at a later time. For every choice during the study, different colored meeples was used to indicate that the choices impacted a different Recipient. See SI Movie S5 for an example of the full study procedure. The procedure was modified for the Hadza due to the practical need to shorten the study for subjects, details of the full procedure and the modified Hadza procedure are available in the Supplementary Information (pg.25, 28). All scripts were translated and then back-translated.

Comprehension checks: At the start of the study, subjects demonstrated that they understood that a larger quantity of tokens would produce the most rewards, and all participants answered questions to indicate that when watching the videos they attended to the location of tokens, and remembered the content of the norm primes (for example, the experimenter pointed to 1/1 and asked "is this right or wrong?", then pointed to 2/0 and asked "is this right or wrong?") (Supplementary Information pg.24-25). No participants who passed these comprehension questions were excluded from the sample.

Rewards: Within the study, rewards were represented as tokens (e.g. glass beads, stones, etc.). Subjects were informed that "the more tokens they received, the more rewards they would receive", but the precise nature of the rewards or the exchange rate was not communicated to child participants. The exception to this was for the Hadza, where the use of tokens was not understood by participants, and small candies were used directly within the study in place of tokens (see the descriptions of the modified Hadza procedure, below). For children, rewards were sourced locally, and usually consisted of candy or small food items, or small items like stickers, glow in the dark bracelets, or pens/pencils. Adult participants were in most cases told what the nature of the rewards would be (e.g., money), and the general amount usually obtained by participants, but they also understood that the exact amount would be determined by their choices in the study. At one site (Pune), adults were not told what the reward would be, they were simply told that they would be obtaining "prizes". After the study, tokens were exchanged for rewards. This either occurred immediately for each participant, or it occurred later after all subjects had participated, with the rewards being distributed to all participants at the same time.

Statistical modeling approach: All data were binary choices taking the form of "0" (choice of 2/0) or "1" (choice of 1/1), so we model subjects' choices using regression with a binomial link function. For multilevel models, the posterior distribution of the model can be most easily estimated using Markov Chain Monte Carlo. When using Markov chain Monte Carlo, we generate model predictions by processing many samples from the posterior distribution of the model. Each sample of parameter values from the posterior can be plugged into the model, producing a predicted value for any observable variable. Since the distribution of the samples approximates the posterior distribution of the parameters, the distribution of predictions generated from a large number of samples will approximate the target predictive distribution. Examples of this approach can be found throughout [46].

Data was analyzed in the R Environment for Statistical Computing [47], with most models specified using the function 'MAP' (R package 'rethinking') [46], a convenience tool for fitting a large number of different regression models. Multilevel models were specified and run using a variant of Hamiltonian Monte Carlo (an algorithm particularly good with high dimension models) implemented in RStan [48]. Models were specified using weakly informative priors, which reduce overfitting and also help the Markov chain to converge to the posterior distribution more effectively than flat priors. The posterior distribution we present here is based on 5000 samples from three chains (after 1000 adaptation steps), for a total of 12000 samples. These samples were sufficient to establish convergence to the target posterior distribution. We assessed convergence through the R-hat Gelman and Rubin statistic (R-hat values greater than 1.01 can indicate that the chain did not converge), and the effective number of samples for all parameters were substantial (effective numbers of samples much smaller than the actual number of samples can suggest that the chain was not efficient). Readers unfamiliar with diagnosing chain convergence can find an introduction in Chapter 8 of [46].

Data Availability

The authors declare that all data supporting the findings of this study are available within the Supplementary Information files: "Supplementary_Information_R_code_and_data.zip"

Code Availability

The authors declare that all code supporting the findings of this study are available within the Supplementary Information files: "Supplementary_Information_R_code_and_data.zip"

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Author Contributions

B.R.H. and J.B.S. conceived the project and designed the study. P.K., H.C.B., T.B., A.E., S.L.L., C.S.E., and A.M.S. also contributed to study design. B.R.H., P.K., H.C.B., T.B., S.C., A.E., S.L-L., C.S-E., A.M.S., S.Y. and A.N.C. collected data. B.R.H. analyzed the data, B.R.H. and J.B.S. wrote the manuscript, P.K. and H.C.B. also contributed significantly to writing. All authors contributed to writing the Supplementary Information.

Figure Legends

Figure 1: Arrangement of the apparatus and testing area. From left: Pune, India; Phoenix, USA; La Plata, Argentina.

Figure 2: Results of Models 1b, 2, and 3. 2a: Results of Model 1b, estimating the probability that adults chose 1/1 in the eight societies. Horizontal lines and shaded regions represent regression estimates and 95% CIs (functions 'MAP' and 'link'; R package 'rethinking'). Circles and vertical lines represent proportions and 95% CIs of the raw data (function 'binom.confint', R package 'binom'; for exact proportions see Supplementary Table 2). Triangles represent mean DG offers in a prior study by Henrich and colleagues [4]. **2b**: Results of Model 2, estimating the probability that adults judged the GENEROUS norm prime to be "most correct". Horizontal lines and shaded regions represent regression estimates and 95% CIs (functions 'MAP' and 'link'; R package 'rethinking'; for exact proportions see Supplementary Table 2). Circles and vertical lines represent proportions and 95% CIs of the raw data (function 'binom.confint', R package 'binom'). **2c**: Results of Model 3, estimating how adults' 1/1 choices are predicted by whether they judged GENEROUS to be "most correct", and by the estimated probability that someone in their society would judge GENEROUS to be "most correct". The black line reflects the weak prior distribution, red the posterior distribution for the Estimated Prob. of Society Judgment parameter (Supplementary Table 4), blue the posterior distribution for the Subject's Own Judgment parameter (Supplementary Table 4).

Figure 3: Results of Models 4b, 5, 7 and 8. 3a: Results of Model 4b. Lines represent regression estimates of the probability that children will choose 1/1 in each of the eight societies, as a function of subject age (functions 'MAP' and 'link'; R package 'rethinking'). Circles and vertical bars represent proportions and 95% CIs of adults' choices of 1/1 (function 'binom.confint', R package 'binom'). For model coefficients, see Supplementary Table 5. **3b**: Results of Model 5. The solid line plots the magnitude (and 95% CI) of

the estimated relationship between children's 1/1 choices and the 1/1 choices of adults, as a function of child age (model constructed in Rstan, link: Bernoulli_logit). This captures the emerging positive relationship between older children's DG choices and the DG choices of adults' from their society. The negative values of the effect size for the youngest children is due to young children in Berlin and La Plata being the least likely to choose 1/1 despite adults from those societies being the most likely to choose 1/1. For model coefficients, see Supplementary Table 6. **3c**: Results of Model 7. The solid line plots the magnitude (and 95% CI) of the estimated relationship between children's 1/1 choices and the 1/1 choices of adults, as a function of child age (model constructed in Rstan, link: Bernoulli_logit). This captures the emerging positive relationship between older children's DG choices and the DG choices of adults from their society. **3d**: Results of Model 8. The solid line plots the magnitude (and 95% CI) of the estimated relationship between children's 1/1 choices and adults' judgments as to whether or not the GENEROUS norm prime is 'most correct', as a function of child age (model constructed in Rstan, link: Bernoulli_logit). This captures the emerging positive relationship between older children's DG choices and judgments about norms by adults from their society.

Figure 4: Results of Models 6c and 6d. 4a: Lines and shaded regions represent regression estimates and 95% CIs for the probability that children will choose 1/1 in the GENEROUS, BOTH OK, and SELFISH norm prime conditions, combining samples from the six different societies (functions 'MAP' and 'link'; R package 'rethinking'). **4b-4g**. Lines and shaded regions represent regression estimates and 95% CIs for the probability that children will choose 1/1 in the GENEROUS, BOTH OK, and SELFISH norm prime conditions, for each of the six different societies (functions 'MAP' and 'link'; R package 'rethinking').

Tables

Table 1: Populations sampled. For more details see Supplementary Table 1.

Population [Location]; Description	N Adult (female)	N Child (female)	Child age range (in years)	Children received which norm priming conditions?
German [Berlin, DEU]; Urban	32 (17)	111 (56)	4.07 - 13.36	BOTH OK, GENEROUS, SELFISH
Argentinian [La Plata, ARG]; Urban	29 (13)	133 (65)	4.95 - 13.86	BOTH OK, GENEROUS, SELFISH
Wichí [Misión Chaqueña, ARG]; Rural, sedentized hunter-gatherers	30 (19)	87 (47)	6.47 - 13.61	BOTH OK, GENEROUS, SELFISH
American [Phoenix, USA]; Urban	37 (19)	176 (92)	4.02 - 12.63	BOTH OK, GENEROUS, SELFISH
Indian [Pune, IND]; Urban	30 (16)	155 (75)	4.11 - 13.92	BOTH OK, GENEROUS, SELFISH
Shuar [Amazonia, ECU]; Rural, small-scale horticulture, hunting	20 (8)	58 (27)	6.59 - 15.32	BOTH OK, GENEROUS, SELFISH
Tanna [Tafea provice, VUT]; Rural, small-scale horticulture, hunting	52 (27)	81 (43)	5.74 - 13.53	BOTH OK only
Hadza [Great Rift Valley, TZA]; Rural, foraging, hunting	25 (12)	32 (10)	7.00 - 17.00	BOTH OK only

Table 2: Model comparisons for Models 1a-1c. Using WAIC and AIC weight.

Model #	Model Parameters	WAIC (SE)	dWAIC (dSE)	AIC weight
1a	Intercept only	355.00 (1.37)	26.00 (10.22)	0.00
1b	**Society D[8]**	**329.10 (10.27)**	**0.00 (NA)**	**0.95**
1c	Society D[8], Age, Age X Society D[8], Gender, Gender X Society D[8]	334.80 (11.07)	5.70 (3.71)	0.05

"D" indicates a dummy parameter, "Society D[X]" indicates that multiple dummy parameters were used for X number of societies. The model with the lowest WAIC provides the best fit, dWAIC indicates the difference in WAIC between the focal model and the best-fit model, and dSE indicates the standard error for the difference in WAIC. Where AIC weight is substantially larger for the best-fit model, this implies that it provides a substantially better fit to the data. Where dWAIC is larger than dSE, this also implies that the best-fit model provides a substantially better fit to the data. All comparisons were conducted using the 'compare' function in the R package 'rethinking', with n=40000 samples from the posterior for computing WAIC. **Bold** indicates the models that provide the best fit to the data.

Table 3: Model comparisons for Models 4a-4d. Using WAIC and AIC weight.

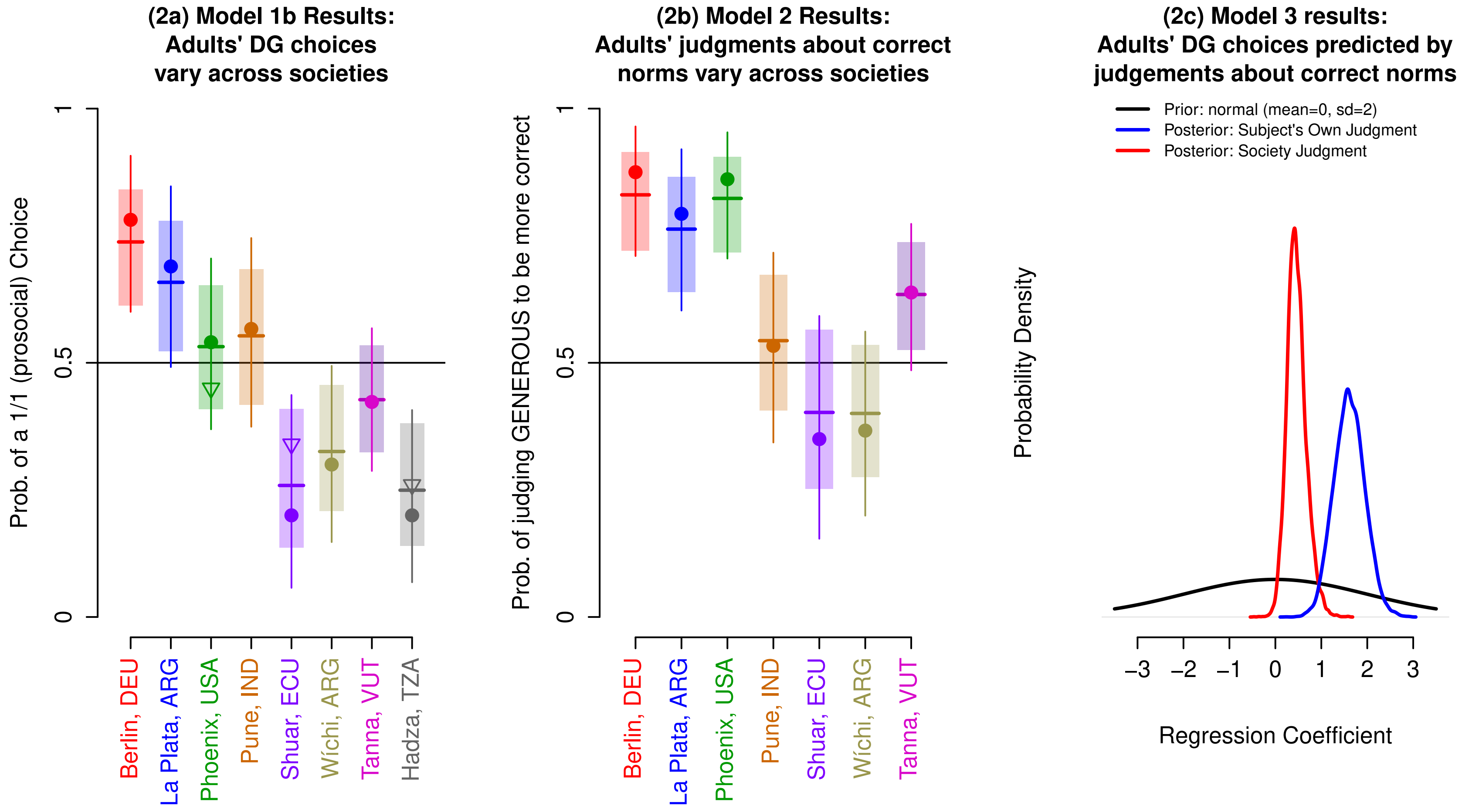
Model #	Model Parameters	WAIC (SE)	dWAIC (dSE)	AIC weight
4a	Society D[8]	411.00 (16.46)	7.90 (7.97)	0.02
4b	**Society D[8], Age, Age X Society D[8]**	**403.10 (17.62)**	**0.00 (NA)**	**0.80**
4c	Society D[8], Age, Age X Society D[8], Age^2, Age^2 X Society D[8]	407.40 (17.88)	4.40 (3.55)	0.09
4d	Society D[8], Age, Age X Society D[8], Gender, Gender X Society D[8]	407.20 (18.02)	4.20 (4.12)	0.10

“D” indicates a dummy parameter, “Society D[X]” indicates that multiple dummy parameters were used for X number of societies. All comparisons were conducted using the ‘compare’ function in the R package ‘rethinking’, with n=40000 samples from the posterior for computing WAIC. **Bold** indicates the models that provide the best fit to the data.

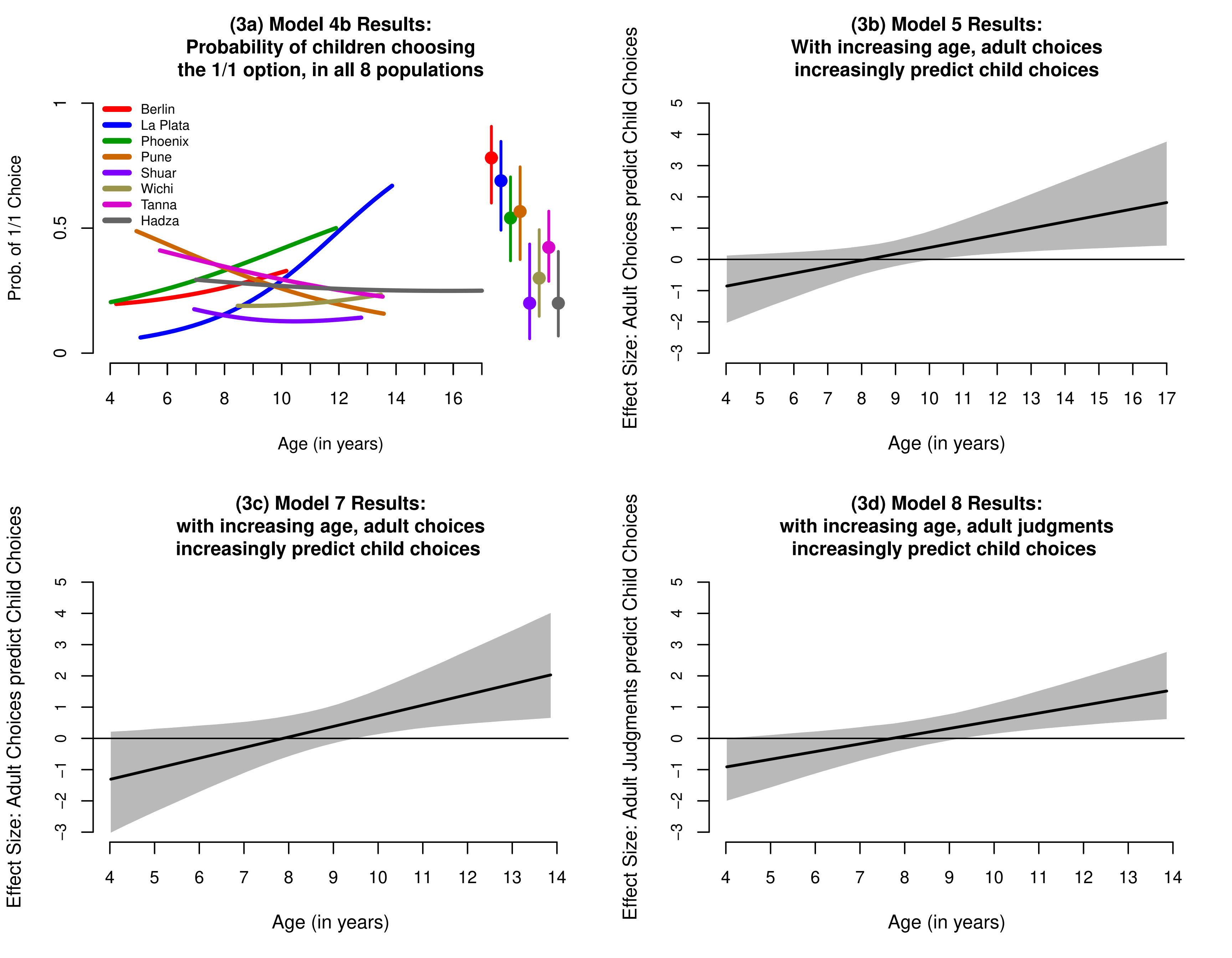
Table 4: Model comparisons for Models 6a-6d; using WAIC and AIC weight.

Model #	Model Parameters	WAIC (SE)	dWAIC (dSE)	AIC weight
6a	Society D[6], Age, Age X Society D[6]	883.20 (21.77)	136.60 (22.40)	0.00
6b	**Society D[6], Age, Age X Society D[6], GENEROUS D, SELFISH D**	**747.00 (27.90)**	**0.30 (4.05)**	**0.45**
6c	**Society D[6], Age, Age X Society D[6], GENEROUS D, SELFISH D, Age X GENEROUS, Age X SELFISH**	**746.60 (28.16)**	**0.00 (NA)**	**0.53**
6d	Society D[6], Age, Age X Society D[6], GENEROUS D, SELFISH D, Age X GENEROUS, Age X SELFISH, Age X GENEROUS X Society D[6], Age X SELFISH X Society D[6]	754.00 (28.69)	7.40 (6.91)	0.01

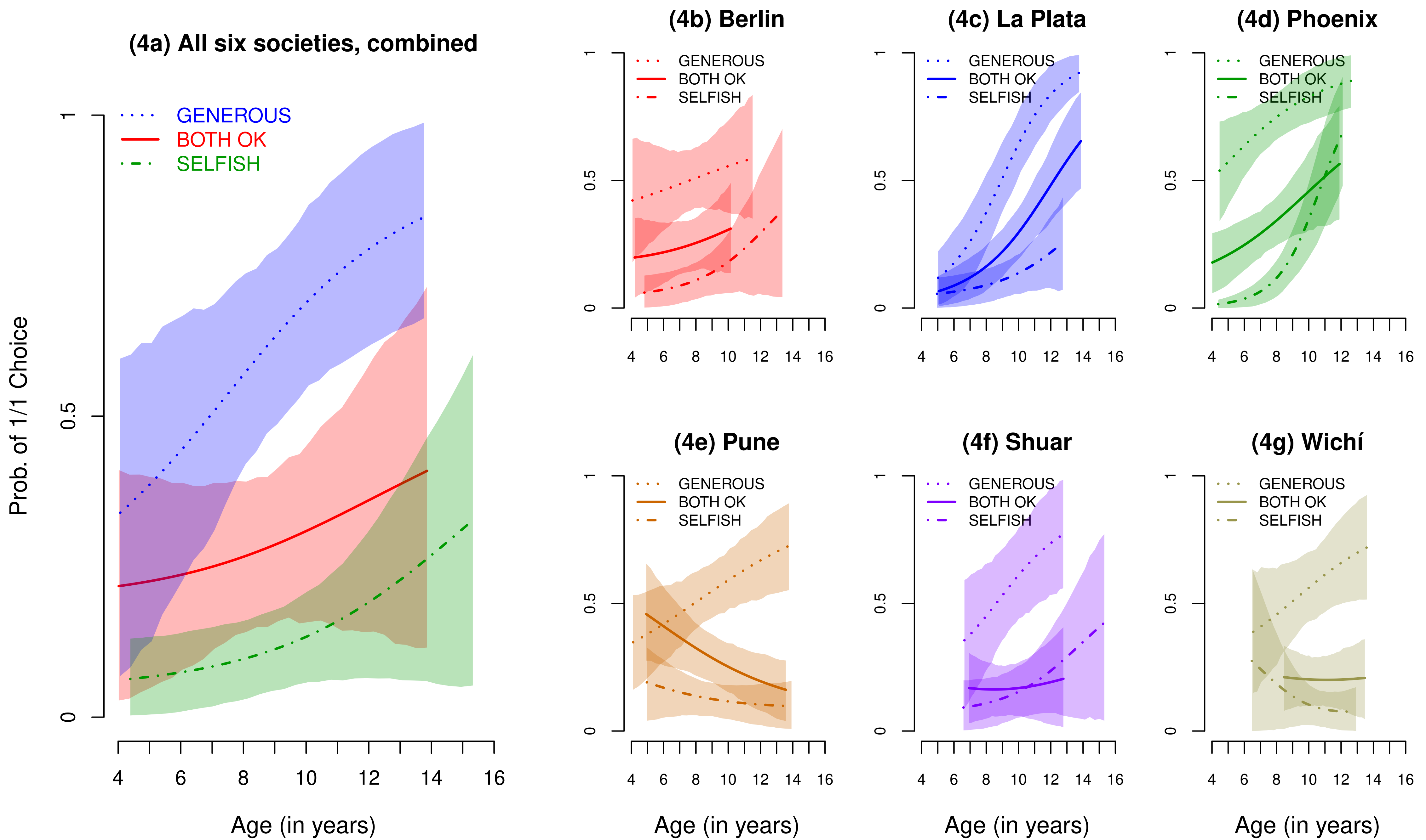
"D" indicates a dummy parameter, "Society D[X]" indicates that multiple dummy parameters were used for X number of societies. All comparisons were conducted using the 'compare' function in the R package 'rethinking', with n=40000 samples from the posterior for computing WAIC. **Bold** indicates the models that provide the best fit to the data.



(2a) Model 1b Results:
Adults' DG choices
vary across societies
Prob. of a 1/1 (prosocial) Choice
1
0.5
0
Berlin, DEU
La Plata, ARG
Phoenix, USA
Pune, IND
Shuar, ECU
Wichi, ARG
Tanna, VUT
Hadza, TZA
(2b) Model 2 Results:
Adults' judgments about correct
norms vary across societies
Prob. of judging GENEROUS to be more correct
1
0.5
0
Berlin, DEU
La Plata, ARG
Phoenix, USA
Pune, IND
Shuar, ECU
Wichi, ARG
Tanna, VUT
(2c) Model 3 results:
Adults' DG choices predicted by
judgements about correct norms
Prior: normal (mean=0, sd=2)
Posterior: Subject's Own Judgment
Posterior: Society Judgment
Probability Density
−3
−2
−1
0
1
2
3
Regression Coefficient



(3a) Model 4b Results:
Probability of children choosing
the 1/1 option, in all 8 populations
Prob. of 1/1 Choice
Berlin
La Plata
Phoenix
Pune
Shuar
Wichi
Tanna
Hadza
Age (in years)
(3b) Model 5 Results:
With increasing age, adult choices
increasingly predict child choices
Effect Size: Adult Choices predict Child Choices
Age (in years)
(3c) Model 7 Results:
with increasing age, adult choices
increasingly predict child choices
Effect Size: Adult Choices predict Child Choices
Age (in years)
(3d) Model 8 Results:
with increasing age, adult judgments
increasingly predict child choices
Effect Size: Adult Judgments predict Child Choices
Age (in years)


(4a) All six societies, combined
GENEROUS
BOTH OK
SELFISH
Prob. of 1/1 Choice
Age (in years)
(4b) Berlin
(4c) La Plata
(4d) Phoenix
(4e) Pune
(4f) Shuar
(4g) Wichí